Planning Scheme Amendment C317 City of Greater Geelong Planning Scheme, 321-399 Ibbotson Street Expert Statement - Flooding

Report Number: R.M00037.001.00.docx
Date: 8 December 2015

Prepared for: Costa Property Nine Pty Ltd

Instructed by: Minter Ellison

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1 Summary of Opinion

It is my opinion that:

- The flood modelling work undertaken by TGM is fit-for-purpose for assessing the proposed development at 321-399 Ibbotson Street;
- The proposed development will not cause increased flood level on any private property external to the Site;
- The proposed development provides a benefit to the surrounding existing residential properties by reduce flood level and flood hazard;
- Safe egress can be provided to and from the Site into the St Leonards Township.

2 Introduction

2.1 Background

Costa Property Nine Pty Ltd (Applicant) is seeking an amendment to the City of Greater Geelong (Council) Planning Scheme for the rezoning of land at 321-399 Ibbotson Street (Site), St Leonards from Farming Zone to General Residential Zone. The application also seeks approval for a staged multi-lot subdivision for conventional residential lots.

A part of the Site is currently flood prone. Consulting engineering firm TGM Group Pty Ltd (TGM) was engaged by the Applicant to prepare a Stormwater Management Plan (SWMP) to address, amongst other things, the management of flood impacts and risks. In late 2014 I was engaged by the City of Greater Geelong to undertake an independent technical review of the preliminary SWMP (TGM, 2014). This review made a number of recommendations for improving the modelling and reporting. These recommendations were mostly addressed in consultation with myself and Council late last year.

In October 2015 the Applicant sought my input to work alongside TGM in finalising the flooding inputs to the SWMP. Given my previous role as an independent reviewer for Council their permission was sought and obtained for me to work in this role. Since that time I have worked with TGM in addressing the remaining recommendations and resolving residual issues with regards to flood impacts and hazard. At the time of writing I have reviewed the final modelling results that will inform TGM's addendum report (TGM 2015[b]), however I have not reviewed the document itself. This will be done prior to the hearing.

2.2 Scope of Works

This expert witness statement was prepared at the request of Minter Ellison. Specifically I was instructed to prepare a report for Amendment C317 addressing the issue of potential flooding both within and outside the proposed development, and including any recommendations to address these issues. The statement does not provide detailed reporting on the analysis methodology and findings, which are provided in the TGM (2015[a] and 2015[b]), but instead summarises the key issues around the modelling and findings.

2.3 Details of Expert Witness

I am a Director at Venant Solutions Pty Ltd. My qualifications include a Bachelor of Engineering (Civil) degree from the Queensland University of Technology, and Master of Engineering Science and Doctorate of Philosophy degrees from the University of Queensland. The degrees at the University of Queensland were undertaken through the Department of Civil Engineering and focussed on hydraulic engineering and fluid mechanics. My PhD topic was Flood and Debris Loads on Bridges. My curriculum vitae is in Appendix A.

I have 27 years of experience as an engineer, 25 of these in the field of hydrology and hydraulics. My areas of expertise include hydrologic and hydraulic modelling of rural and urban catchments, floodplain risk management, and stormwater management. I have personally undertaken analyses on well over 100 catchments throughout Victoria, Tasmania, New South Wales and Queensland.

In preparing the statement I have relied upon the modelling work undertaken by TGM, but have been sufficiently immersed in the modelling process to have confidence in its outcomes.

Witness Statement

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

Dr Mark Jempson

3 Flooding Characteristics and the Proposed Development

3.1 Existing Flooding Characteristics

The locality of the Site is shown in Figure 3-1 and the existing case 1% AEP (annual exceedance probability) flood extent is mapped in Figure 3-2; this mapping is output from TGM modelling which is discussed in Section 4.

A waterway passes through the Site from west to east in the southern part of the Site. South of the creek the Site slopes gently from west to east. North of the waterway the Site rises to about 6 m to 7 m above the creek banks. Flow enters the Site from the west both in the waterway and as overland flow between the waterway and Old St Leonards Road; in the waterway there is an existing 3 cell 2700 mm x 900 mm box culvert under Ibbotson Creek. Overland flow from the south-west also enters the Site near the intersection of Ibbotson Creek and Old St Leonards Road.

The waterway outlets from the Site in the south-eastern corner where there is a 2 cell 2700 mm x 900 mm box culvert under Old St Leonards Road. If the capacity of this pipe is exceeded, the water breaks away from the waterway and flows as surface flow across Old St Leonards road and also to the east across Lake View Crescent. Flow also leaves the existing Site along its southern boundary and crosses Old St Leonards Road.

The flood extent mapping in Figure 3-2 shows that south of the waterway most of the Site is inundated in the 1 % AEP event. Inundation of this part of the Site is predominantly a result of runoff from the catchment to the west and south-west. The mapping also shows that existing residential properties to the south of the site are flood prone under existing conditions.

North of the waterway the flooding on the Site is predominantly shallow overland runoff resulting from rainfall falling directly on to the Site. Most of the runoff from the existing Site flows in an easterly direction and onto the residential properties to the east of the Site. Runoff from the northern extremity of the Site flows north onto the St Leonards Golf Club.

3.2 Proposed Development

This report primarily focuses on the management of the flooding in the waterway and to the south rather than runoff from rainfall directly on to the Site, although the latter is included in the model. Whilst there is proposed development to the north of the waterway, the focus is on the southern part of the Site because it is proposed to construct residential lots in this area as shown in Figure 3-3. This will obstruct existing flow paths and hence careful design is required to ensure that existing flooding in surrounding existing residential properties is not adversely impacted.

Key elements of the design to manage flood risks are as follows (also refer Figure 3-4):

- Two retarding basins are proposed to mitigate increases in discharge resulting from development on the Site;
- The south-western corner of the Site is left undeveloped to provide a flow path to the creek;
- There will be some shaping of the open area in the south-western corner to provide a hydraulically efficient flow path to the creek;

- A new stormwater pipeline and pits is proposed to run south along Ibbotson Street, east along Old St Leonards Road, and then cross under Old St Leonards Road and Murradoc Road to discharge into the downstream waterway;
- Increase the box culvert under Ibbotson Street to a 4 cell 2700 mm x 900 mm box culvert;
- Increase the box culvert under Old St Leonards Road to a 3 cell 2700 mm x 900 mm box culvert and continue this as a sealed structure through to downstream of Murradoc Road rather than out letting in the drainage reserve between Old St Leonards Road and Murradoc Road;
- Retain a single cell 2700 mm x 900 mm box culvert under Murradoc Road to drain the surface flow from drainage reserve;
- Provision of a low level weir at the pinch point between the fill platforms in the south eastern corner to provide additional retardation within the Site;
- The existing 1125 mm diameter stormwater pipe that runs along the southern side of Old St Leonards Road and discharges into the drainage reserve between Old St Leonards Road and Murradoc Road will be extended so that it discharges into the waterway downstream fo Murradoc Road;
- Upgrade Cole Street culvert from a 5 cell 1200 mm x 900 mm box culvert to a 7 cell 1200 mm x 900 mm box culvert – this was retained in the scheme from earlier options testing but it is likely that it will not be required as discussed in Section 5.1.

Management of flood risk was also found to be sensitive to the proposed upgrade of Old St Leonards Road. Currently this road is unsealed with grass table drains on either side. The traffic and transport assessment (Cardno, 2015) recommends sealing the road and providing kerb and channel along the northern side and retaining the table drain fronting the properties on the southern side. This configuration was found to provide an acceptable outcome regarding flood risk as discussed in Section 5. As part of the flood assessment kerb and channel along the southern side was also modelled but it was found that the safety criteria for flooding on roads could not be achieved with this configuration. This was primarily because the road had to be lowered so that the top of kerb could tie in with the existing properties to the south. With the road lowered the depth of flooding on Old St Leonards Road increased with the result that the safety criteria on the road would not be satisfied along a section towards the eastern end of the Site.

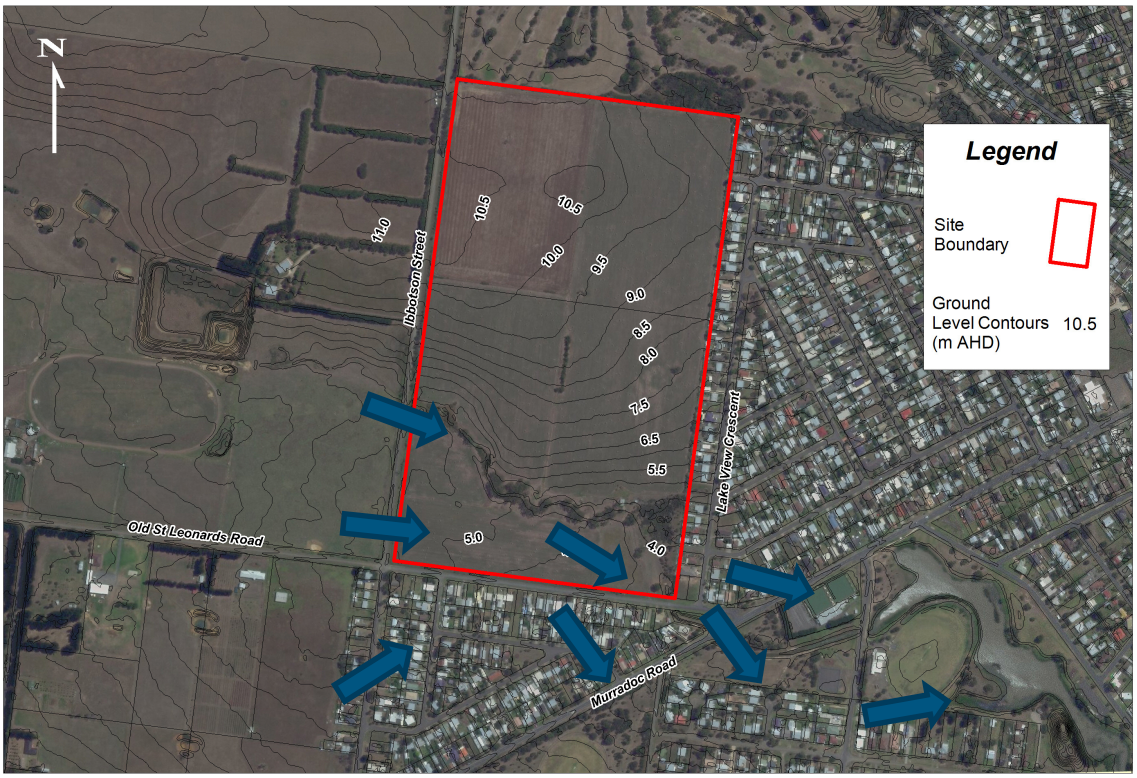


Figure 3-1 Site Locality and Indicative Flow Paths from Catchment Flooding

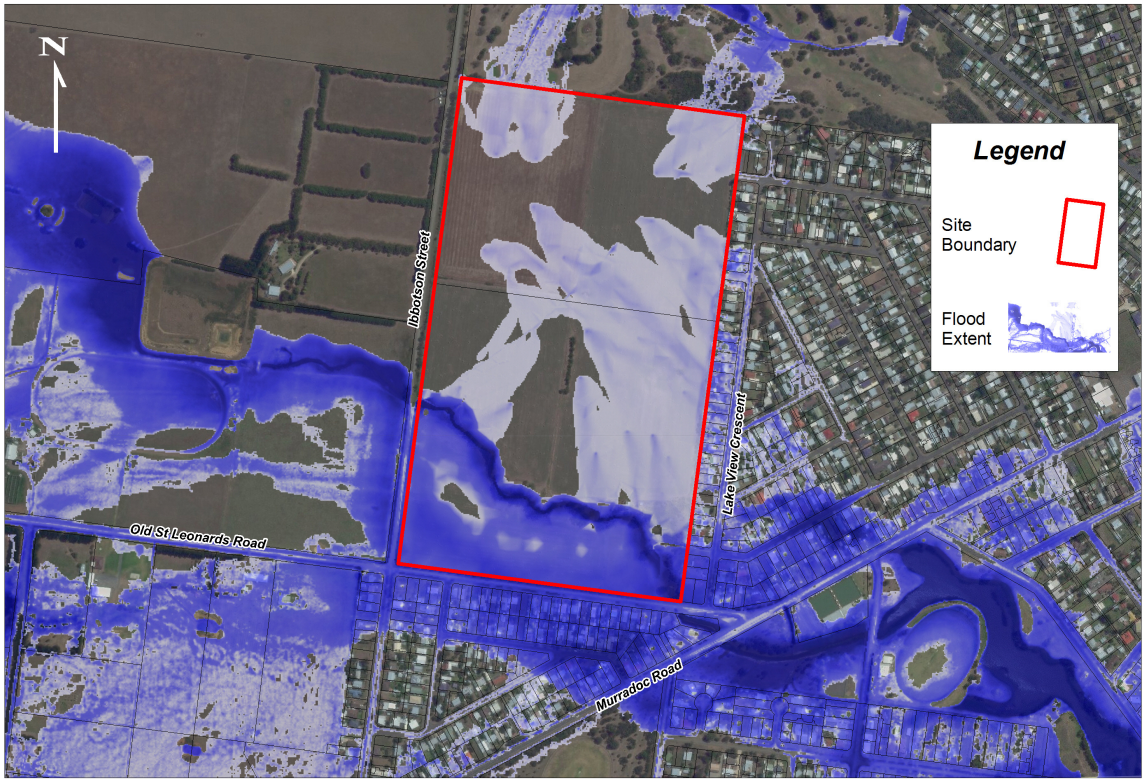


Figure 3-2 Existing Conditions 1% AEP Flood Mapping

Figure 3-3 Proposed Plan of Sub-division

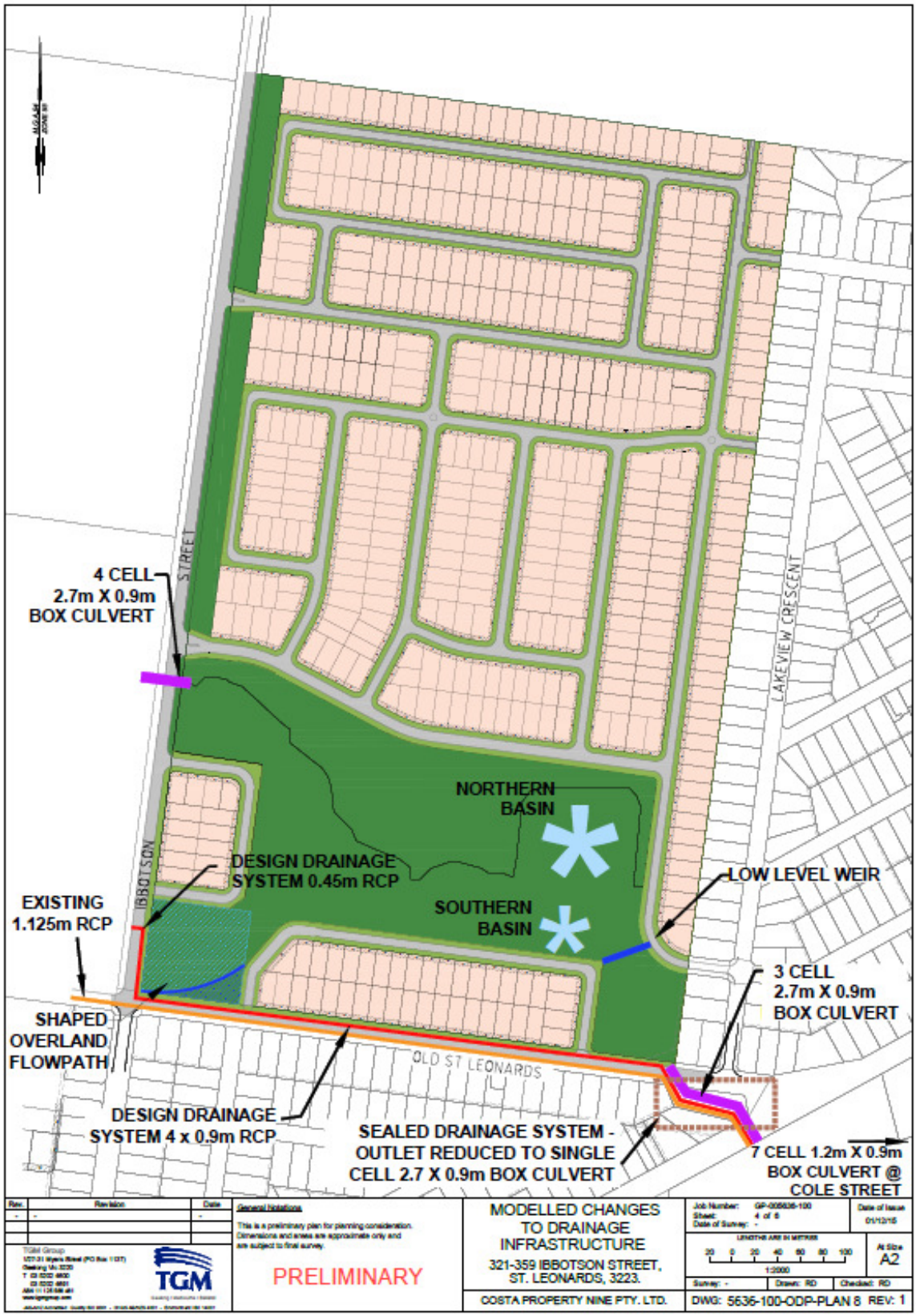


Figure 3-4 Key Flood Management Design Elements

4 Summary of Flood Model Development

The flood model comprises hydrological and hydraulic modelling. The hydrological modelling is of the entire catchment and establishes the amount and timing of runoff from the entire catchment. Hydraulic modelling is typically over a localised area and is used to determine flood levels, depths, extents, velocity and flow direction and changes to these result alterations to the floodplain and drainage systems. The hydraulic model uses the runoff data from the hydrological modelling as inputs.

The hydrological and hydraulic modelling was undertaken by TGM. The modelling uses industry standard software (XP-RAFTS hydrological software and TUFLOW 2 dimensional hydraulic software) and is considered to be best practice for this type of assessment. As noted in the introduction I undertook on behalf of the City of Greater Geelong an independent technical review of the preliminary SWMP (TGM, 2014), including a review of the hydrological and hydraulic modelling. This review made a number of recommendations for improving the modelling and reporting. In consultation with myself and Council in late 2014 and early 2015 TGM fully implemented the recommendations pertaining to the hydrologic modelling and mostly implemented the recommendations pertaining to the hydraulic modelling. The revised modelling was documented in TGM (2015[a]), but it did not assess flood impacts and risks associated with the proposed development as a masterplan had not been finalised at that time.

As noted in the Introduction I was engaged by the Applicant, with the permission of Council, to work with TGM in implementing the remaining recommendations to the hydraulic modelling and to assist in refining the design to achieve a satisfactory outcome with regards flood impacts, risk and safety. TGM have now implemented the remaining recommended changes to the hydraulic modelling. I have subsequently reviewed the model and consider it to be fit-for-purpose for assessing the proposed development. The hydraulic model covers an area significantly larger than the area that influences or is influenced by the proposed development. I have not reviewed these areas of the model that are not influential for the proposed development and as such my endorsement of the model does not extend beyond its intended use for this application.

I have also been closely involved with TGM in the iterative modelling undertaken to achieve a satisfactory design solution and are of the opinion that the modelling of the design case is fit-for-purpose. One point to note with regards the hydraulic modelling is that the stormwater pipe network internal to the Site is not included in the model as it has not been designed at this stage. The pipe network is proposed to have a 10% AEP design capacity and so for the 50%, 20% and 10% AEP storm events the runoff has been input as a boundary directly into the retention basins. In the 5%, 2% and 1% AEP events the flow boundaries have been applied directly to the street network to demonstrate the flow paths through the Site and allow an assessment of the Site egress. This is a conservative analysis as in these large events a portion of the flow will be in the pipe network.

5 Summary of Flood Impact and Site Egress

The hydraulic modelling was used to assess the following:

- 1% AEP flood level for the purpose of setting fill levels at or above this level;
- Impact of the proposed development on flood levels on existing residential properties on floods ranging from the 5% AEP through to the 1% AEP;
- Satisfying site egress from the development in the 1% AEP event.

Full details of the assessment methodology can be found in TGM (2015[b]).

5.1 Flood Impact

The impact on flood level caused by the proposed development is mapped in Figure 5-1 to Figure 5-6. In these figures, the lemon colours show area where the flood impact is in the range -0.005 m to 0.005 m, whilst the green colours represent reductions in flood level and the beige/orange/red shades represent increases in flood level in accordance with the ranges shown in the legend. The pink shade shows areas that were flooded under existing conditions but would now be dry with the development in place, and the blue shade shows areas that were dry and would now be wet.

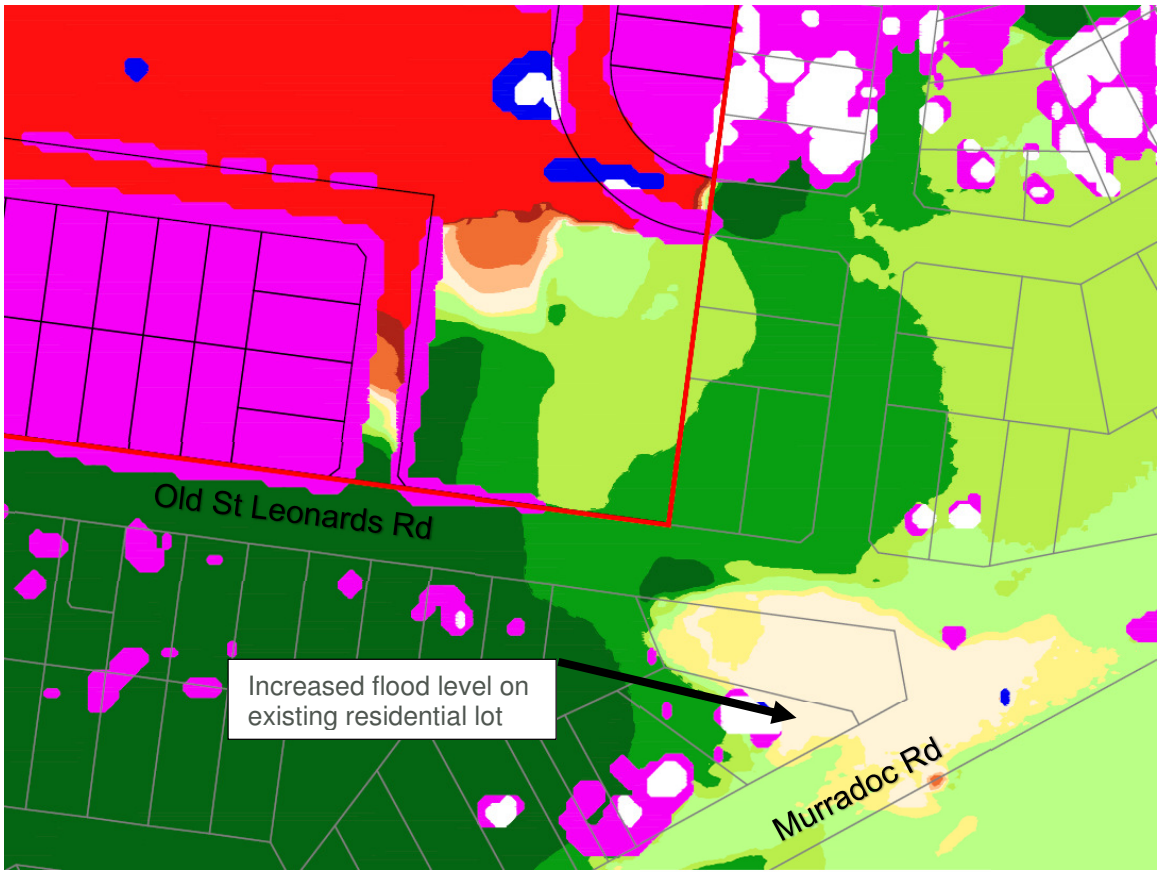
The dominant colour shades on these figures are pink and green which indicates that the development is either removing flooding or reducing flood levels. These benefits provided by the proposed development extend over a large number of existing residential properties.

In the 1% AEP event there is one existing property where there is an increase in flood level in the range 0.005 m to 0.03 m as shown below in the Excerpt 1 from Figure 5-1; there are decreases in flood level on this property in smaller events. At the time of writing this is being investigated further. The likely cause is the proposed change to the stormwater pipes in the drainage reserve next to the property, in particular the proposed change to the drainage configuration under Murradoc Road (refer Section 3.2 and Figure 3-4). Under existing conditions there are box culverts under Old St Leonards Road that convey water from the Site into the drainage reserve. It is proposed to continue these culverts through to the downstream side of Murradoc Road so that they do not outlet into the drainage reserve. Because of this the full capacity of the two cell 2700 mm x 900 mm box culvert under Murradoc Road would not be required to drain the drainage easement and it was reduced to one cell 2700 mm x 900 mm box culvert. It appears that this may have been too much of a reduction in the capacity and increasing the size is being investigated. Further investigations are being under taken and will be presented at the Panel Hearing.

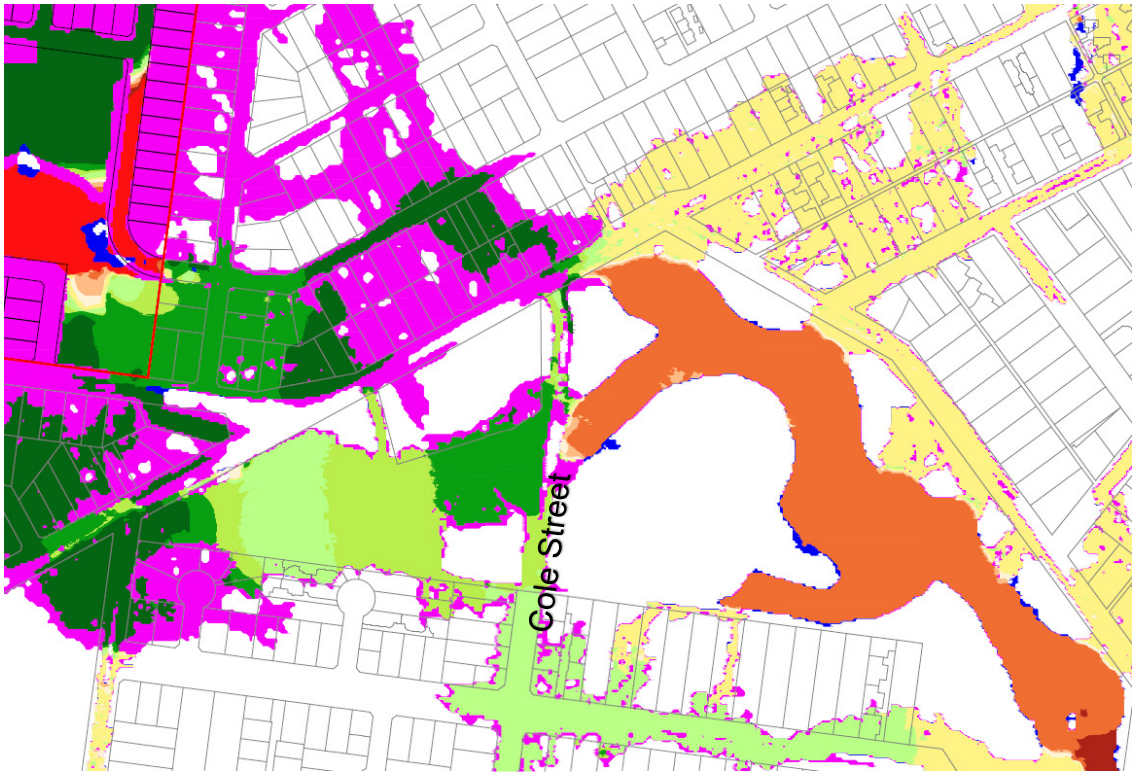
In the 5%, 10% and 20% AEP events there are increases in flood level downstream of Cole Street (see Excerpt 2 from Figure 5-3), but decreases upstream. The increases are within the St Leonards Lake area and do not impact on residential property. The likely cause is the proposed increase in the number of culvert cells under Cole Street. Given the decreases upstream of Cole Street the changes to the culvert may not be required. Further investigations are being under taken and will be presented at the Panel Hearing.

In the various events tested there are also increases in flood level and/or “was dry now wet” as shown below in the Excerpt 3 from Figure 5-1 (1% AEP). These are not real impacts but are an artefact of the model boundary conditions. In these area the boundary condition type is called a source-area which means that the runoff is distributed evenly to all wet cells in the model; at the start of the simulation when the area is fully dry the boundary initially distributes to the low point until more of the model gets wet. In these areas the flood extent has changed in the developed case because of the reductions in flood level caused by the development. This means that the model boundary distributes the runoff slightly differently between the existing and developed case, which is not a real effect.

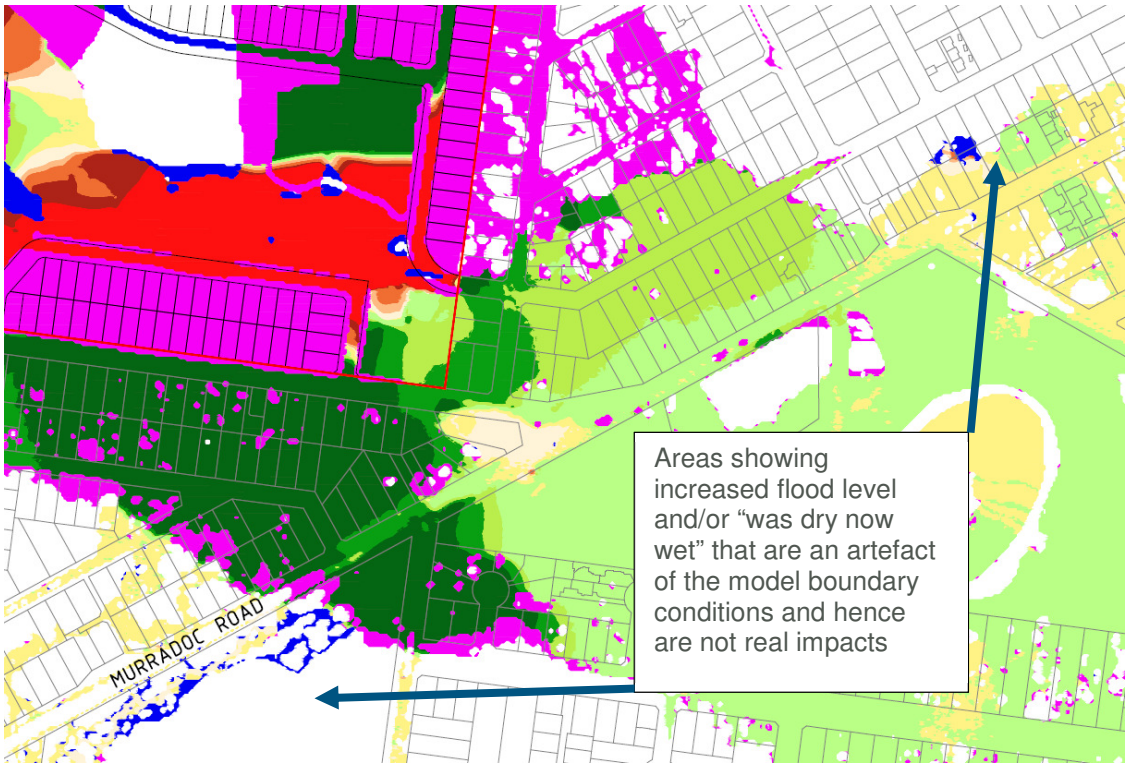
In the 50% AEP event there is an increase in flood level in Flinders Road and Henty Road that are not evident in the larger events (see Excerpt 4 from Figure 5-6 below). This occurs because the changed road surface and changed Old ST Leonards Road/Flinders Rd intersection is directing a small amount of additional water down these roads. This is being investigated further and is expected to be resolved by the Panel Hearing.



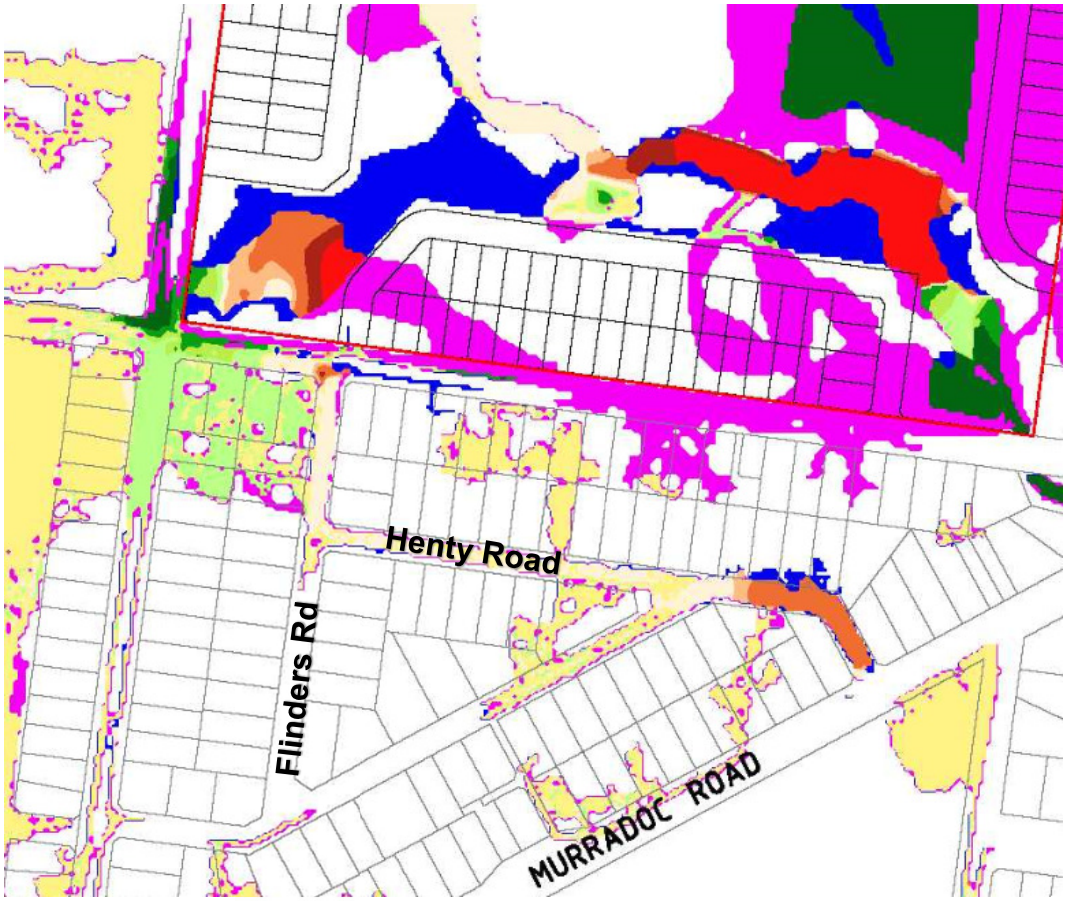
Excerpt 1 from Figure 5-1



Excerpt 2 from Figure 5-3



Excerpt 3 from Figure 5-1



Excerpt 4 from Figure 5-6

5.2 Site Egress

When developing on a floodplain, CoGG and CCMA require that safe vehicle egress during a 1% AEP event is provided. CoGG defers to Melbourne Water's guidelines [(MW, 2008) and (MW, 1996)] for criteria defining safe egress. The CCMA's letter dated 10/06/2014 (Ref: F-2014-0404) provided the following criteria:

- Depth should be no more than 0.30m; and
- Velocity should be no more than 3.0 m/s; and
- The product of depth and velocity (D.V) should be no more than 0.30 m2/s.

These criteria are the same as those in Australian Rainfall and Runoff Revision Project 10 for small vehicles and were adopted for the assessment on this project. They are marginally more stringent than these in the Melbourne Water Guidelines.

The 1% AEP developed case depth and D.V are mapped in Figure 5-7 and Figure 5-8. Velocity mapping is not included as the velocity is well below the 3.0 m/s. In these figures an areas is mapped as safe if it is below the above criteria and unsafe if it exceeds the criteria. Figure 5-9 is an envelope

of Figure 5-7 and Figure 5-8 with unsafe areas given the preference in the mapping. The existing case depth and D.V are mapped in Figure 5-11 and Figure 5-12.

In comparing Figure 5-7 and Figure 5-8 it can be seen that the roads in the broader area are safe using the D.V criterion but there are a number of locations where they are classified as unsafe using the depth criterion. This indicates that it is a low velocity environment with depths just exceeding the criterion.

Within the Site all roads are safe under both criteria, noting that this is a conservative analysis with no flow in stormwater pipes within the development as would be the case in reality.

Safe egress to and from the Site is also available as shown in Figure 5-10. At the southern end of Ibbotson Street the egress arrow are shown as heading north. At the southern end of Ibbotson Street the Dav (average depth across the street) just exceeds the 0.3m but it is expected that this can be reduced to within the acceptable limits with some modification to the road design and increasing the size of the new pipes proposed along Ibbotson Street in this area. The southern exit onto Lake View Crescent just exceeds the depth criterion (see Figure 5-7), but this is shown as an egress route. Similarly it is expected that this can be resolved. These matter are being further investigated and will be presented at the hearing.

A comparison between the existing case and developed case depth hazard mapping (Figure 5-11 and Figure 5-7) shows that the development significantly reduced the number of existing residential lots within the unsafe area. It also reduces the unsafe area along Old St Leonards Road and a number of the side streets such as Lake View Crescent, Flinders Road and Henty Road. A comparison of the existing and developed case D.V hazard mapping (Figure 5-12 and Figure 5-8) shows that the proposed development results in a small reduction in the sections of unsafe road.

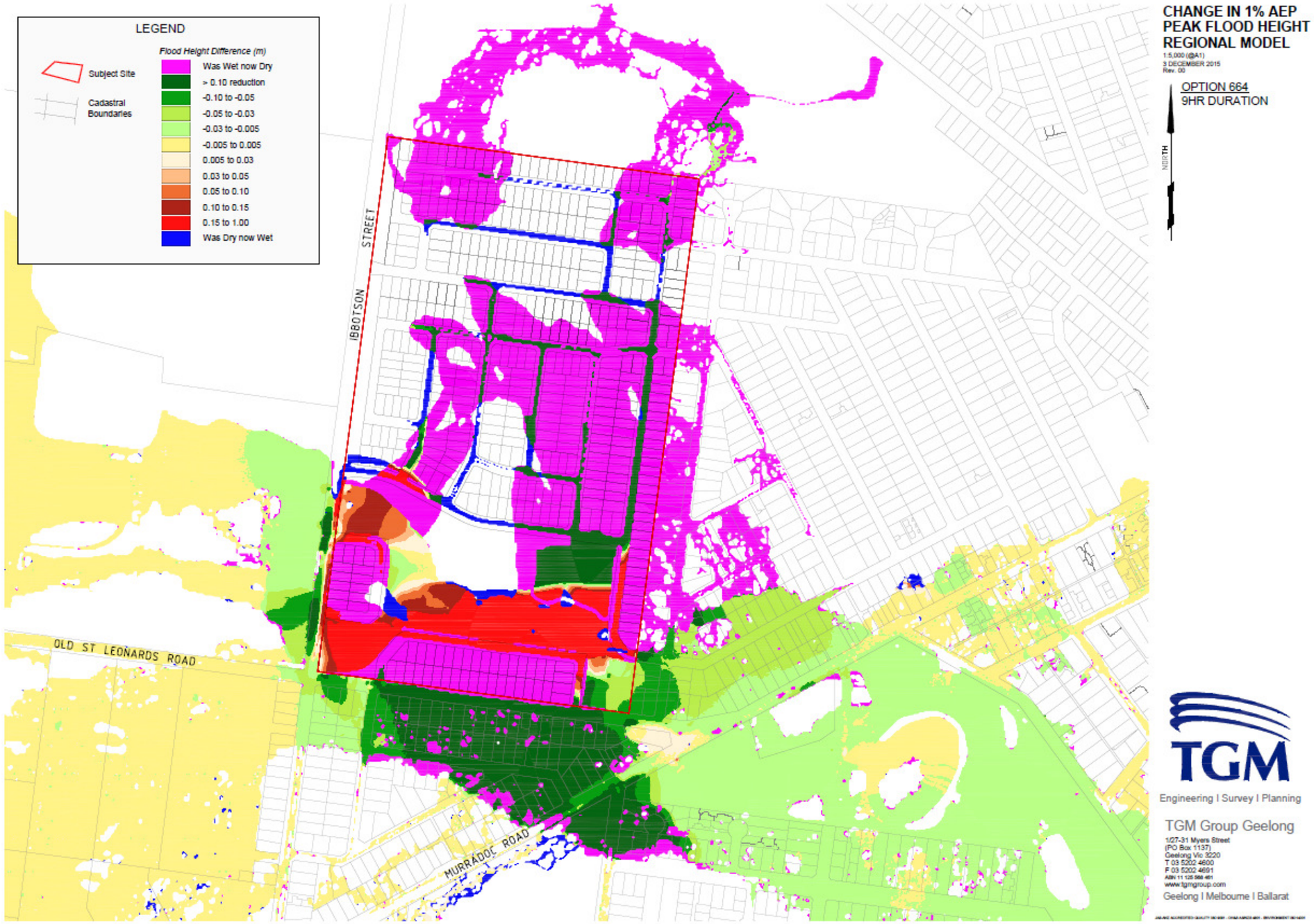


Figure 5-1 Change in Peak Flood Level – 1% AEP

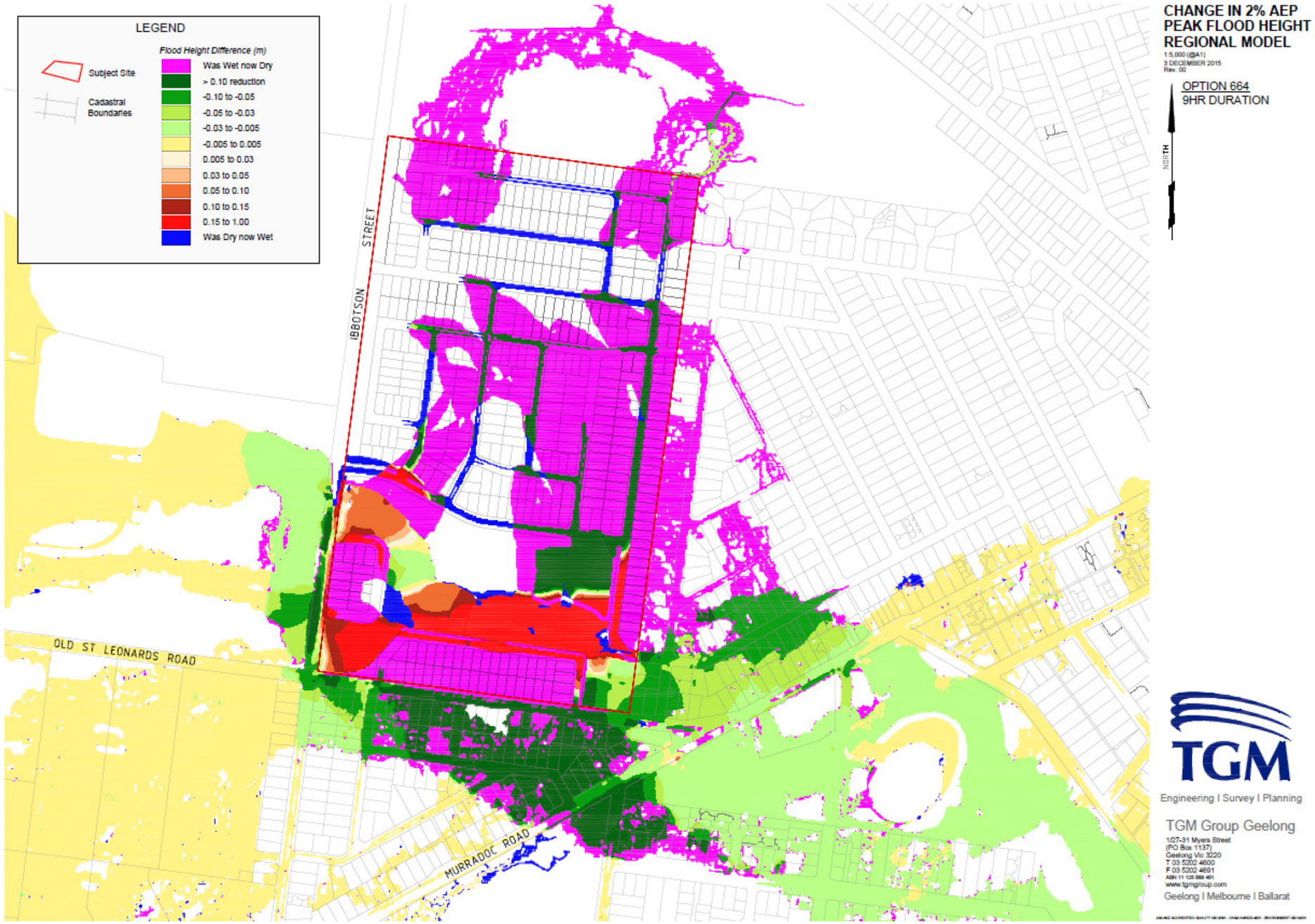


Figure 5-2 Change in Peak Flood Level – 2% AEP

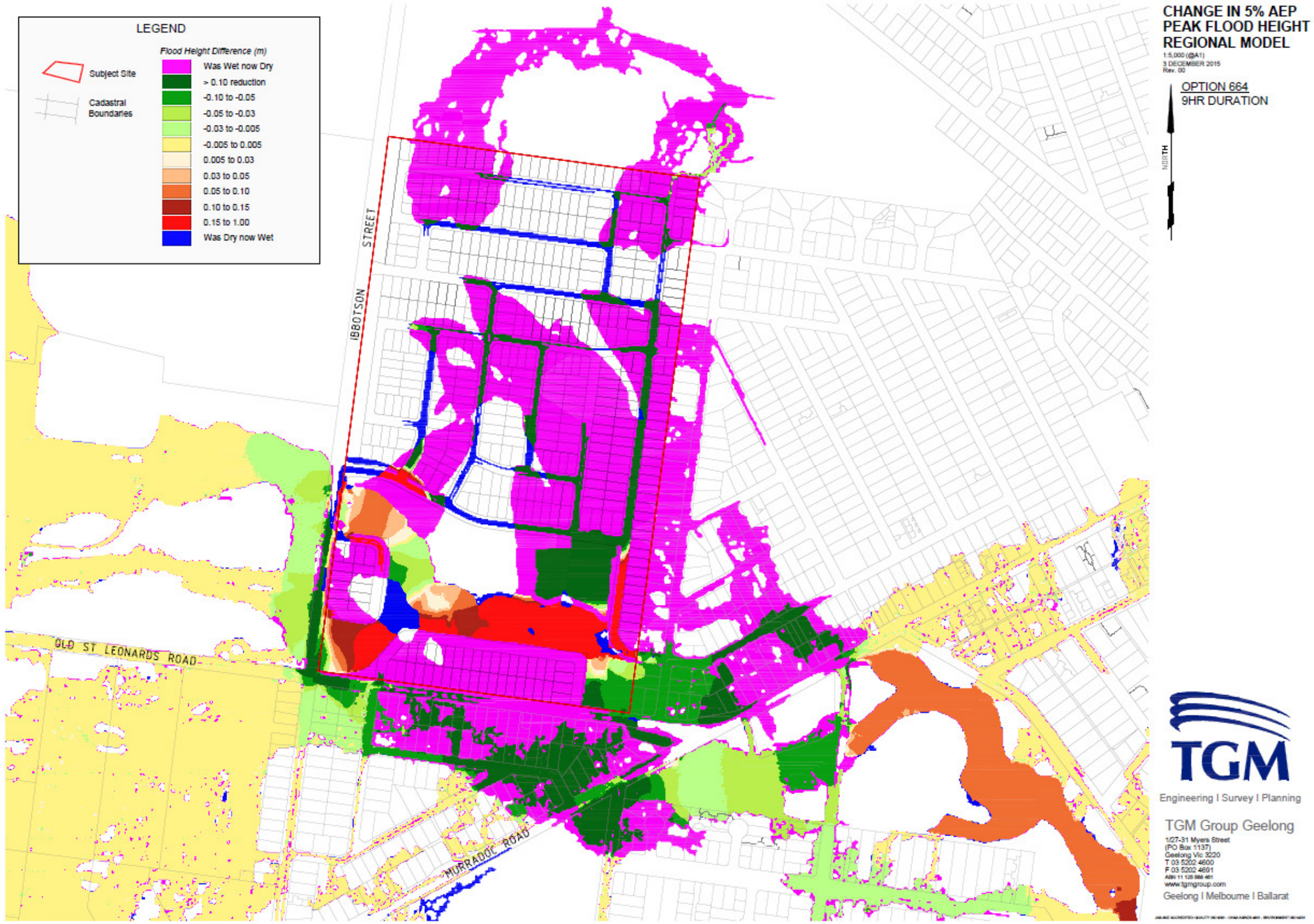


Figure 5-3 Change in Peak Flood Level – 5% AEP

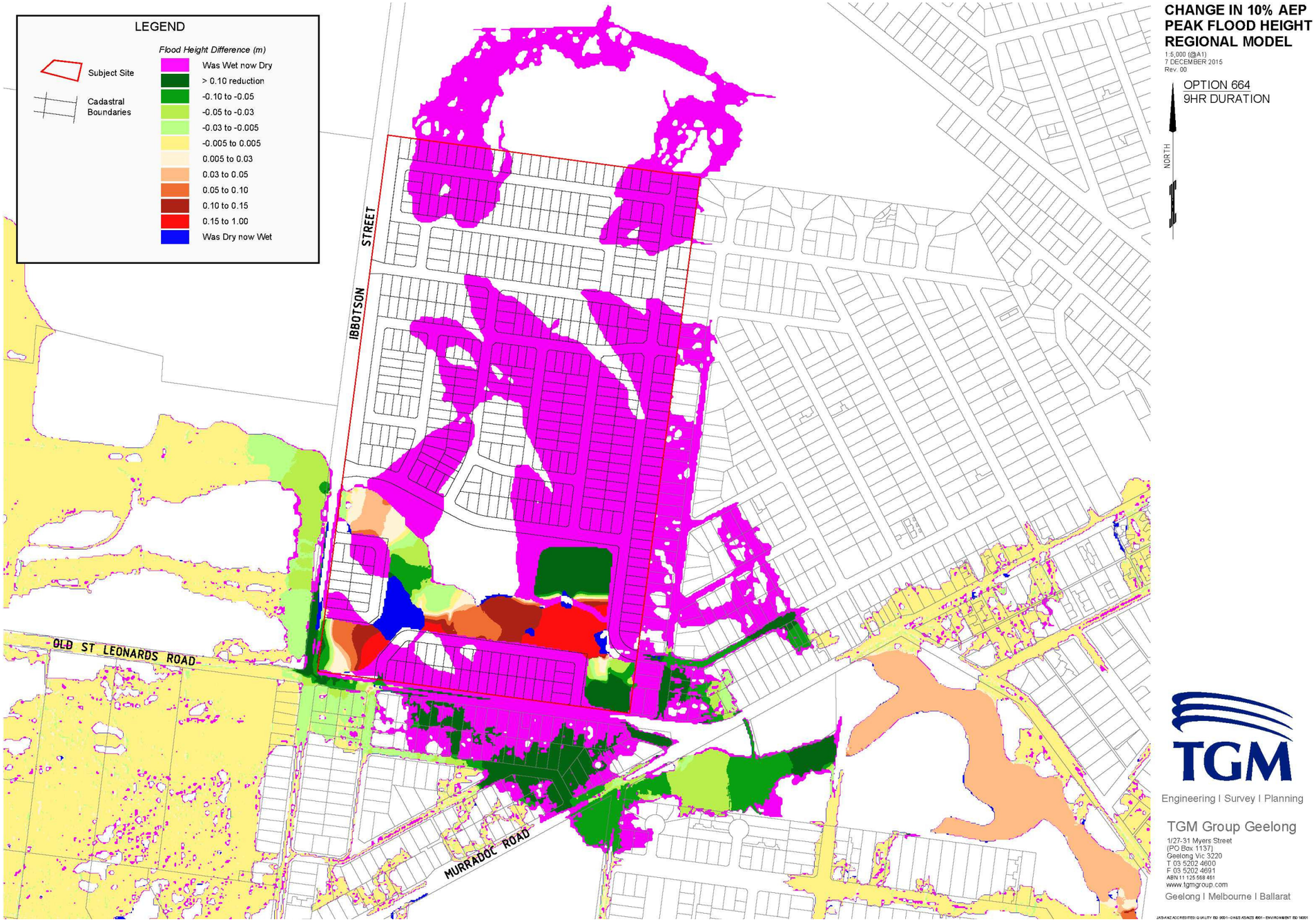


Figure 5-4 Change in Peak Flood Level – 10% AEP

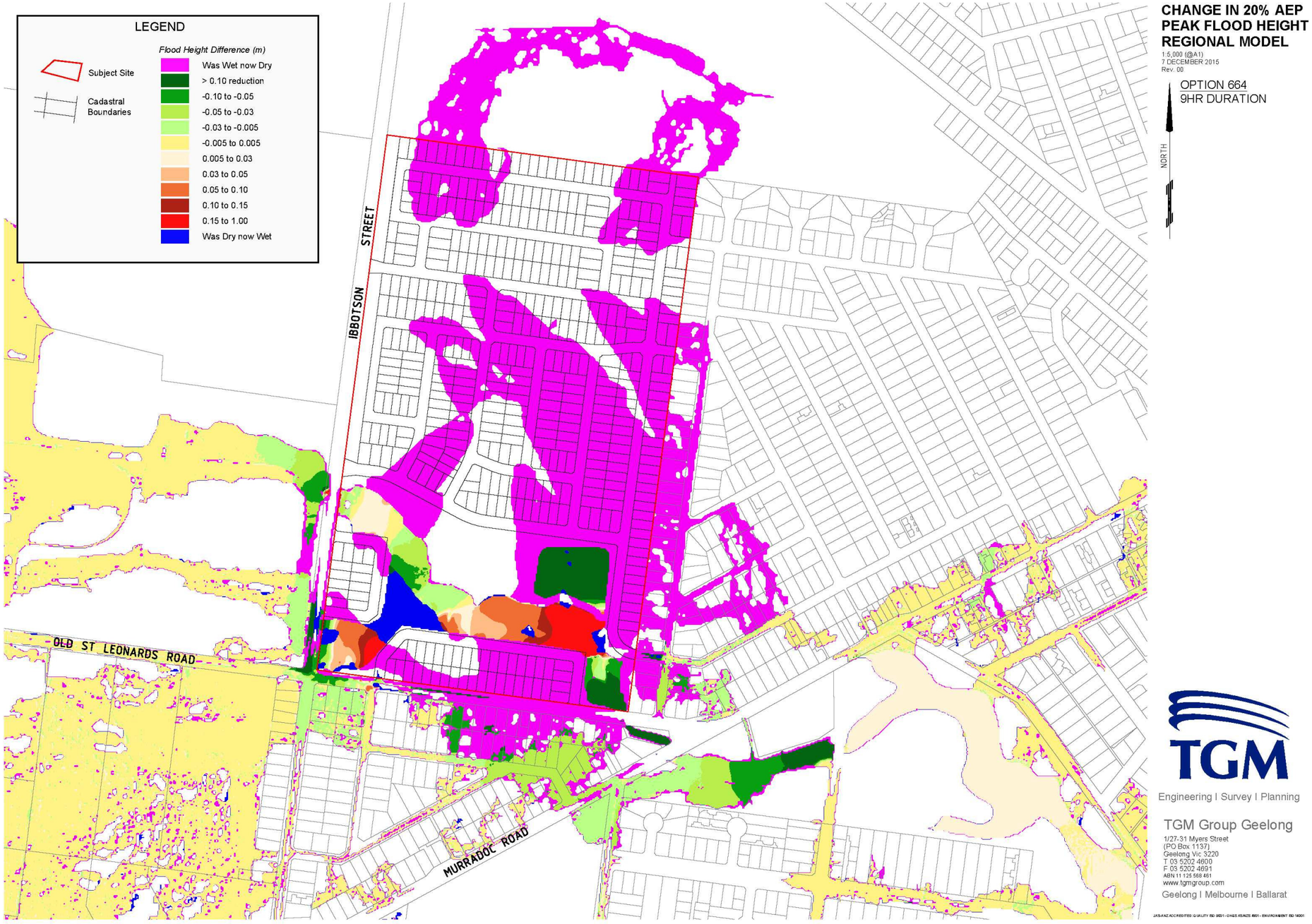


Figure 5-5 Change in Peak Flood Level – 20% AEP

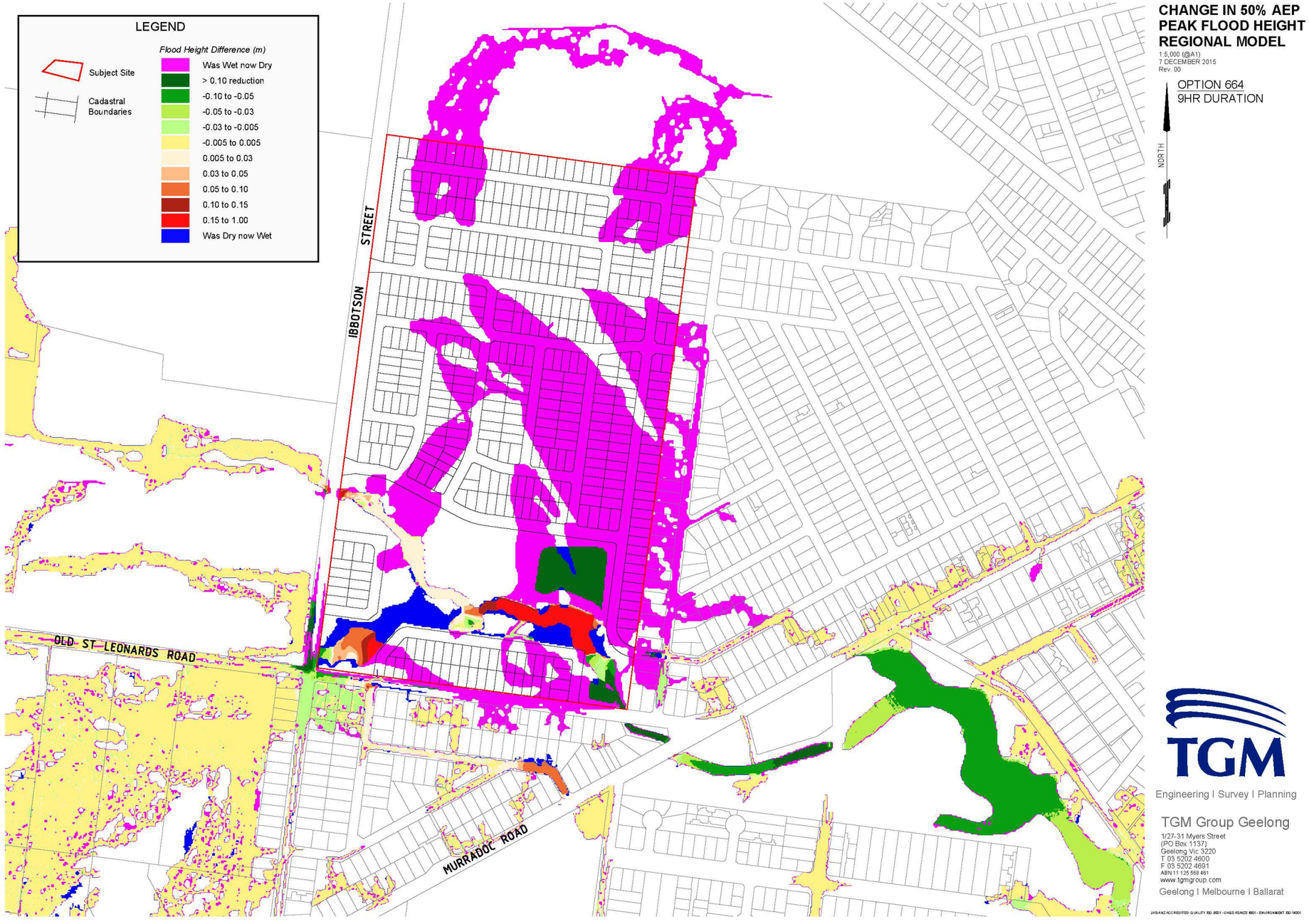


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Figure 5-6 Change in Peak Flood Level – 50% AEP

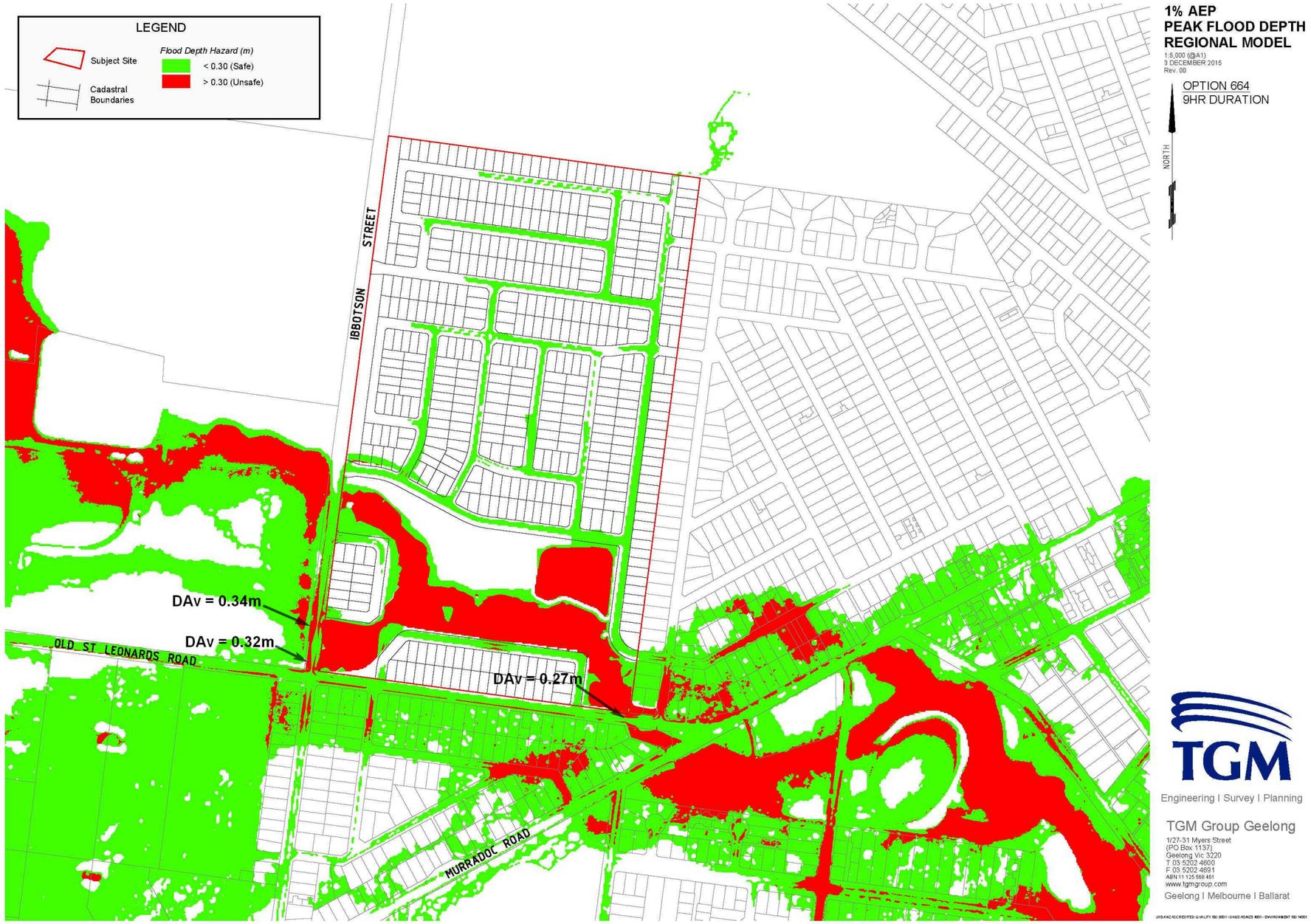

Figure 5-7 Depth Hazard Mapping – 1% AEP Developed Case

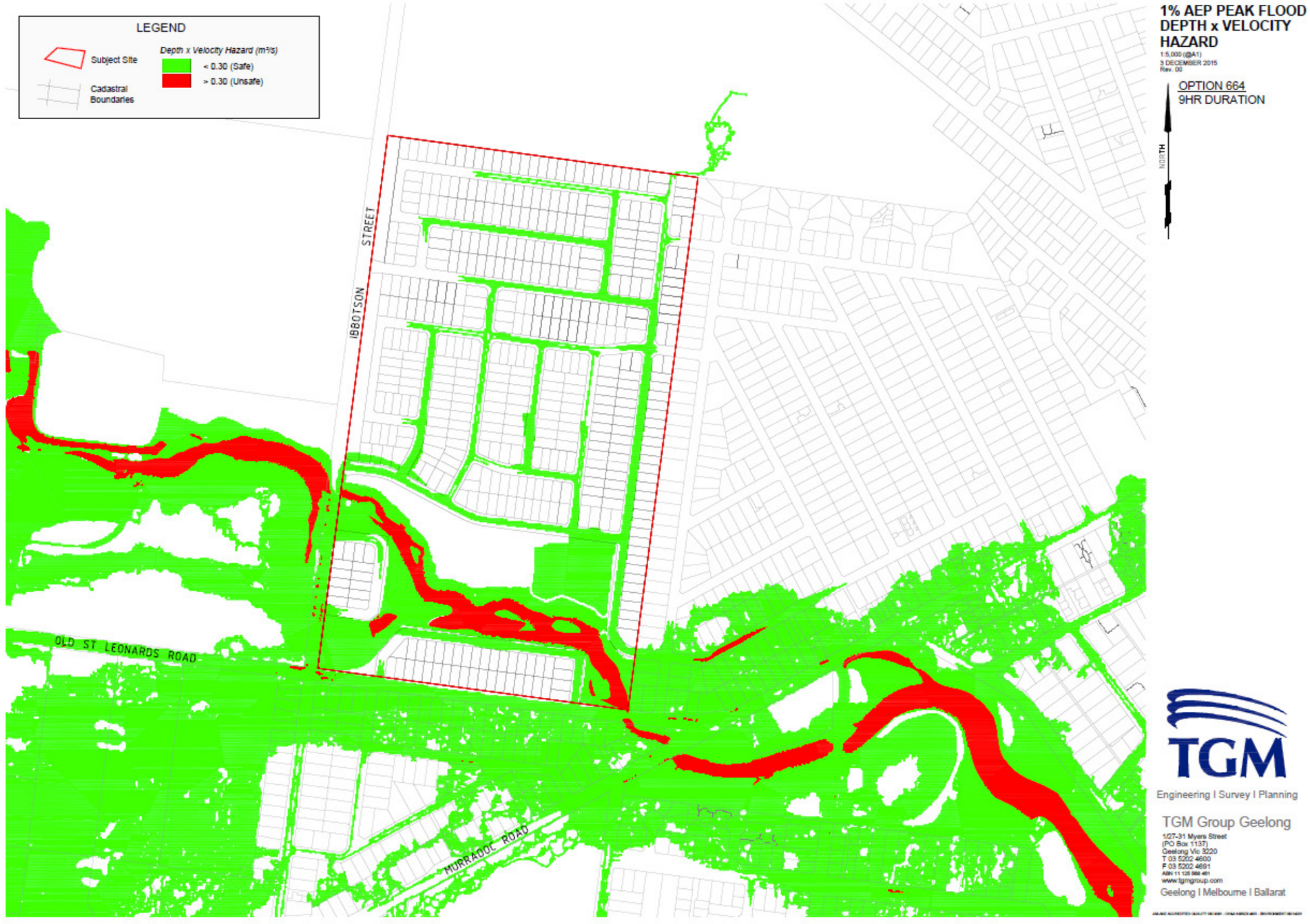

Figure 5-8 Depth x Velocity Hazard Mapping– 1% AEP Developed Case

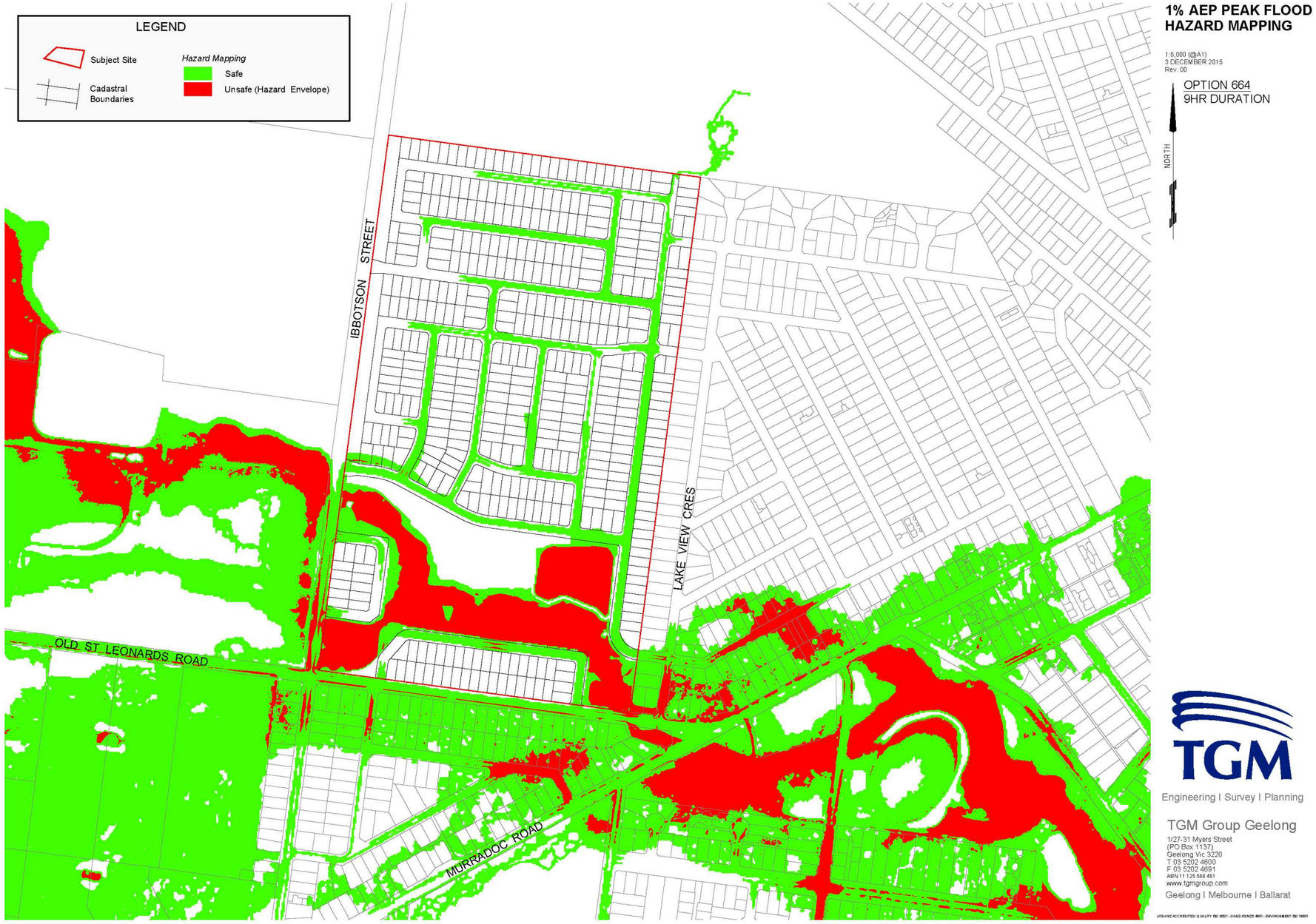

Figure 5-9 Envelope of Depth and Depth x Velocity Hazard Mapping – 1% AEP Developed Case

Figure 5-10 Site Egress Routes – 1% AEP Developed Case

Figure 5-11 Depth Hazard Mapping – 1% AEP Existing Case

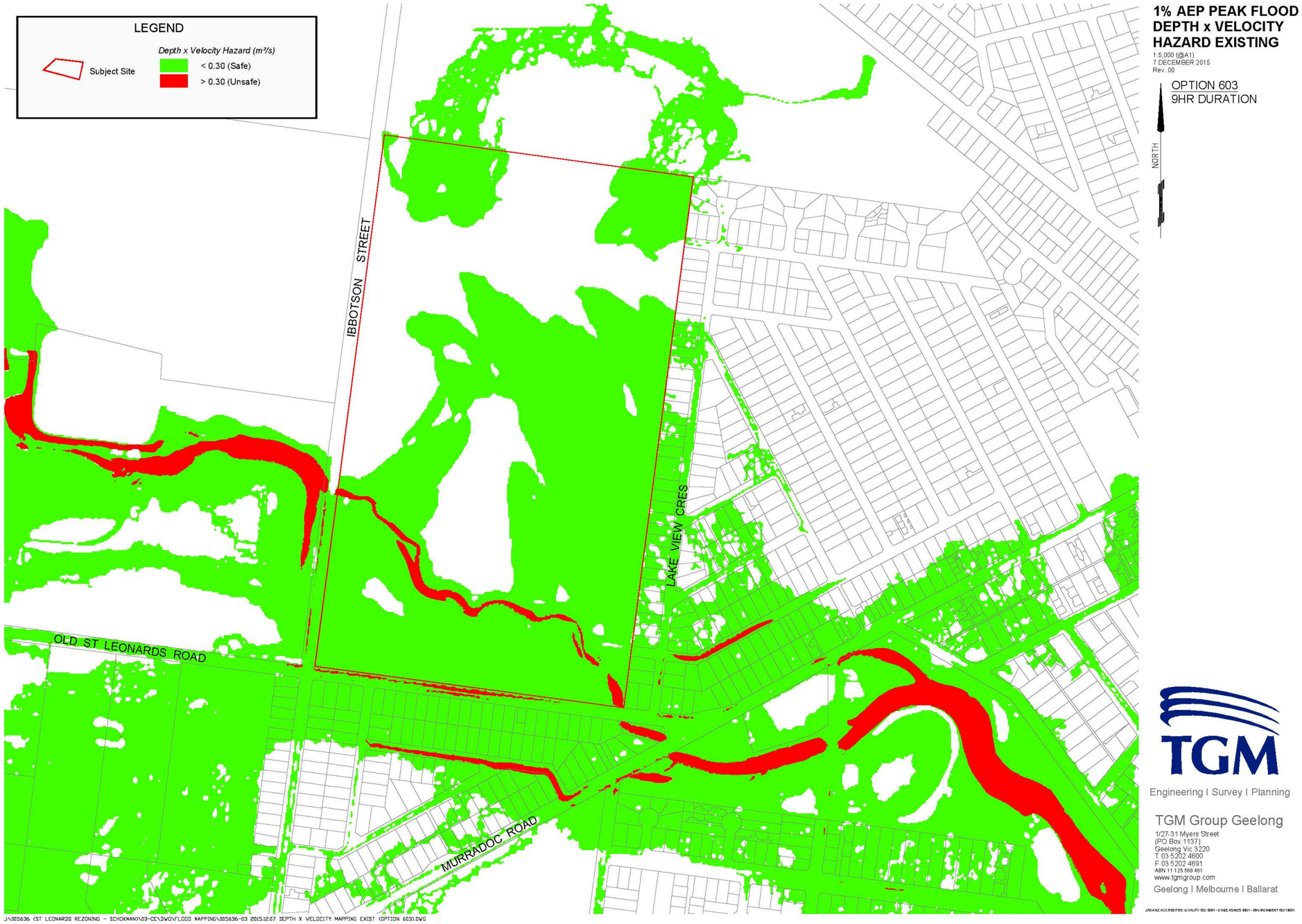

Figure 5-12 Depth x Velocity Hazard Mapping– 1% AEP Existing Case

6 References

Cardo (2015), *Traffic and Transport Assessment Ibbotson Street Subdivision – Growth Area 1*, Report prepared by Cardno for TGM Group Pty Ltd, Report No. CG140338REP001F04, 28 August 2015

MW (1996), *Floodway Safety Criteria - Model Guidelines Version*, Melbourne Water, Version 2 May 1996

MW (2008), *Guidelines for Development in Flood-prone Areas*, Melbourne Water, Version 1.1, October 2008

TGM (2014), *321-399 Ibbotson Street St Leonards Stormwater Management Plan Preliminary Report*, Report prepared by TMG Group Pty Ltd for Costa Property Nine Pty Ltd, TGM Reference No. 005636-200, July 2014

TGM (2015[a]), *321-399 Ibbotson Street St Leonards Existing Flood Study and Site Stormwater Management Plan Preliminary Report*, Report prepared by TMG Group Pty Ltd for Costa Property Nine Pty Ltd, TGM Reference No. 005636-200, August 2015

TGM (2015[b]), *321-399 Ibbotson Street St Leonards Hydraulic Model Update & Flood Impact Assessment Report – Addendum 1*, Report prepared by TMG Group Pty Ltd for Costa Property Nine Pty Ltd, December 2015

Appendix A Mark Jempson's Curriculum Vitae

Dr Mark Jempson

Director

Qualifications and Accreditations

PhD in Civil Engineering, Hydraulics, University of Queensland.

Master of Engineering Science, University of Queensland.

Bachelor of Civil Engineering, Queensland University of Technology

Member, Engineers Australia

Chartered Professional Engineer (CPEng)

National Professional Engineers Register (NPER)

Registered Professional Engineer of Queensland, Civil (RPEQ)

Past Chair, Engineers Australia Victorian Water Engineering Branch

Summary

Mark has twenty-seven years industry experience in hydrological, hydraulic and multidisciplinary environmental investigations, construction and bridge design. Mark has worked in both the government and private sectors; 10 and 17 years respectively.

Mark is recognised as one of Australia's leading experts in flood modelling, floodplain management and road and bridge hydraulics. He has undertaken studies across Victoria, Queensland, New South Wales, Tasmania, South Australia and the UK involving hydrologic and hydrodynamic modelling and flood management of estuaries, rivers and floodplains, water quality investigations and environmental assessments.

Aside from the management of projects, Mark is regularly called on as a peer reviewer and expert witness by government agencies and the private sector in Queensland, New South Wales and Victoria. Mark has excellent communication skills, honed from many years of community consultation, and is able to effectively communicate complex flooding issues and analysis techniques to those without a technical background.

Mark's PhD research topic was *Flood and Debris Loads on Bridges*. Mark was the author of the hydrodynamic and debris load chapters in the Australian Bridge Design Standard.

Mark has hands-on experience in many of the key hydrologic and hydraulic modelling packages including XP-RAFTS, RORB, WBNM, URBS, HEC-RAS, TUFLOW, and MIKEFLOOD / MIKE21 / MIKE11.

Employment History

Current:	Venant Solutions, Director and Founder, Melbourne
2003 – 2013:	BMT WBM Water & Environment Business Unit Manager, Melbourne
1999 – 2002:	BMT WBM Senior Engineer, Brisbane
1988 – 1998:	QLD Department of Main Roads

Areas of Expertise

- Hydrodynamic modelling (1D and 2D)
- Flood hydrology
- Urban and rural flood modelling and mapping
- Floodplain Management
- Expert Witness/Peer Review
- Road and Bridge Hydraulics - author of flood and debris loads in Australian Bridge Design Standard
- Stormwater Quality and Quantity Management
- GIS Mapping

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Key flood management experience

Rural flood and floodplain management studies

These projects typically required the development of a survey brief, hydrologic modelling, two-dimensional hydraulic modelling, hydraulic and economic assessments of structural and non-structural floodplain management options, review of flood warning systems, community and stakeholder consultation, sedimentation assessments, and preparation of floodplain management plans. Following is a list of project in which Mark has been involved either as project manager, project director or technical reviewer.

- Herbert River Flood and Floodplain Management Study (Qld)
- Johnstone River Flood and Floodplain Management Study (Qld)
- River Tamar and North Esk River Flood Study (Tas)
- Mt William Creek Flood Investigation (Vic)
- Upper Wimmera Flood Investigation (Vic)
- Macalister River Flood Study – Stage 1 (Vic)
- Bacchus Marsh Flood and Floodplain Management Study (Vic)
- Yarriambiack Creek Flood Investigation (Vic)
- Lower Kiewa River Flood and Floodplain Management Study (Vic)
- Casterton Flood Intelligence and Warning Improvement Study (Vic)
- Glenelg River Sand Management Hydraulic Modelling Study (Vic)

Urban flood mapping

These studies involve the development of detailed hydrologic and 1D/2D hydraulic models to establish existing flood characteristics, and to provide input into economic and flood damages assessments. Some studies required the assessment of mitigation options and benefit-cost analyses. Clients include Melbourne Water, City of Greater Geelong and City of Greater Dandenong. This list of projects undertaken includes the Western Treatment Plant, Shakespeare Grove and Byron Street Main Drains, Sweetwater Creek, Kilsyth and Bungalook Main Drains, Barwon Heads, Bridge Street and Western Gully, Port Arlington, and Dandenong CBD.

Herbert River Levee Management Study

There has been a significant change in flooding patterns on the Herbert River floodplain since the 1960's as a result of construction of levees by landholders. The construction of the levees, or the expansion of existing levees, continues as landholders respond to increased flooding on their properties. The Herbert River Improvement Trust recognises the need to control future growth of levees if a disaster is to be avoided. This study used flood modelling of future hypothetical levee construction to demonstrate the future impact on flooding. Consultation with landholders and stakeholders was then undertaken to kick start an on-going and long-term education process.

Melbourne Water Development Services Schemes

These projects involve hydrologic, hydraulic and water quality modelling and the preparation of a development services strategy. Functional design of stormwater management measures such as retarding basins and bio-retention systems were undertaken. Quantities and costs of works are determined as input into Melbourne Water's Development charges. Projects undertaken include Central Creek, New Gisborne, Romsey, Riddells Creek, Loch and Nyora.

Impacts of Pontoons and Jetties on Flooding on the Coomera and Nerang Rivers

The Gold Coast City Council was concerned that the on-going construction of pontoons and jetties on the Nerang and Coomera Rivers may impact of flood levels. The Computational Fluid Dynamics (CFD) software Fluent was used to assess the near field effects of the pontoons and jetties. Data obtained from the CFD analysis was used to inform the far-field 2D modelling undertaken using TUFLOW.

Insurance Assessments

Mark worked on hydrology reports for insurance companies following the Victorian floods in 2012 and the Queensland flood in 2013.

Key road and bridge drainage assessments

These studies involved the development of detailed hydrologic and hydraulic models to assist in route selection and the establishment of the road grade and bridge and culvert requirements to meet flood serviceability requirements such as flood impact and time of closure. Bridge scour assessments are sometimes required. Recent major projects include:

- Bruce Highway Upgrade, Haughton River, Preliminary Evaluation Study (Qld)
- Bruce Highway Upgrade, Ingham to Cardwell Range Planning Study (Qld)

- Bruce Highway Upgrade, Frances and Cattle Creeks - Link Study, Business Case and Detailed Design phase
- Bruce Highway Upgrade – Larsens Street to Lannercost Street (Qld)
- Gold Coast Intra-Regional Transport Corridor (Qld)
- Western Highway Duplication – Carpenter Road to Box's Track (Vic)
- Springvale Road - Railway level crossing removal (Vic)

During Mark's 10 years at the QLD Department of Main Roads he spent 8 years working in the flood group undertaking flood assessments on bridge and road project across most parts of Queensland.

Key land development projects

Planning system requirements associated with developing on a floodplain can be complex with regards to flood and stormwater management. Mark has worked for both developers and approval authorities (review and technical advisor role) on many complex development proposals in both Victoria and Queensland from concept through to detailed design and as an expert witness in planning submissions and appeals. A selection of these projects includes:

- Queens Wharf Brisbane (Qld)
- Grand Lakes (Vic)
- Seabank Estate (Vic) – winner of the 2007 UDIA award for WSUD
- Manzeene Avenue (Vic)
- Gold Coast Convention Centre (Qld)
- Pacific View Estate (Qld)
- Gold Coast International Marine Precinct (Qld)

The Queens Wharf Development is a multi-billion dollar redevelopment of the north bank of the Brisbane River in the CBD. The project is a State initiative and Mark worked as a Technical Advisor (flooding) to the State through the 18 month procurement process. This included the preparation of tender documentation, development of a TUFLOW model for use by the Proponents during tendering, assisting with Proponent questions during tendering, technical review of tenders, advising the State on planning matters.

Key environmental modelling projects

River Tamar Estuary Modelling Study

Mark was the Project Manager responsible for the development of a calibrated tidal hydrodynamic, water quality and cohesive sediment transport model of the Tamar River estuary for the Launceston City Council. The modelling was performed using the RMA10S and RMA11 software packages. Cohesive sediment transport and siltation modelling was an important focus of this study which seeks to develop a tool for modelling the ongoing siltation problem within the upper Tamar estuary and for predicting the flood scour which is likely to occur. The model was also used to assess the impact of changes to the Council's wastewater treatment system on the water quality of the Estuary.

Gold Coast International Marine Precinct EIS

An expansion to the marine precinct on the Coomera River is proposed. It is deemed to be a project of state significance by the State. The precinct is in an environmentally sensitive and flood prone area. Mark was responsible for the following assessments: flood and tidal; receiving water quality; sediment accumulation; dredge plume dispersion; sediment impacts on aquatic ecology. The assessments were undertaken on a range of modelling packages including a TUFLOW FV for tide, advection dispersion model (dredge plume dispersion), and sediment accumulation. MIKE21 was used for the flood assessment.

Woollooman Creek Weir

The impact of a proposed weir in combination with an in-stream sand extraction operation on the sediment transport processes within the Creek were assessed. Long-term sediment transport processes, catchment yield and sediment capacity were assessed. Recommendations were developed for mitigating the impacts.

Maroochy River Eutrophication Modelling

The effects on sewage discharges on receiving water quality and estuarine ecological health and proposed plant augmentations were assessed using MIKE11. The eutrophication model investigated nutrient cycling, growth of phytoplankton and zooplankton as well.

Construction and bridge design experience

During his time at QLD Department of Main Roads, Mark spent nearly two years working in road construction and bridge design.

Key peer review experience

Inquiry into Flood Mitigation Infrastructure in Victoria, Parliament of Victoria

Following the Victorian floods of 2010 and of 2011, the Victorian Government established a parliamentary enquiry into flood mitigation

infrastructure in Victoria. Mark was the technical adviser for the enquiry report.

Hawkesbury-Nepean Valley Flood Management Strategy

Infrastructure NSW is proposing a significant investment in a range of flood management strategies for the Hawkesbury-Nepean Valley. NSW Treasury requires that the proposed schemes are independently reviewed. Mark is a member of the peer review panel established by NSW Treasury.

Brisbane River Pedestrian Riverwalk, Peer Review

The Riverwalk pedestrian bridge on the Brisbane River was washed away during the 2011 floods. To minimise the risk of a future failure, the Brisbane City Council's consultant undertook 3D hydrodynamic modelling to determine flow velocities and physical modelling to determine flood force coefficients; the coefficients were required to establish the flood loads.

Mark's PhD research was in flood and debris loads on bridge structures, and so the Council engaged Mark to review the physical modelling and derivation of the force coefficients.

Flemington Racecourse Flood Wall

The Victorian Racing Club proposed the construction of a flood wall around the Flemington Racecourse to reduce the risk of the Melbourne Cup being affected by flooding. Concerns were raised as to the effects of the flood wall on existing developments along the Maribyrnong River floodplain. The City of Melbourne, Moonee Valley City Council and Maribyrnong City Council engaged Mark to complete an independent peer review of the modelling, proposal and mitigation works.

Brisbane Airport Link and Busways, Peer Review of Hydraulic Modelling

The Airport Link and Busways project in Brisbane required the construction of a complex array of bridges/overpasses over Breakfast Creek at Herston. This resulted in a large number of piers in creek and floodplain. With a large number of flood prone houses upstream, it was important that the modelling reliably estimated the impacts of the piers and that appropriate mitigation was implemented. Brisbane City Council engaged Mark to peer review the modelling undertaken by the Proponents' consultants.

Salacia Waters Marina Development, Gold Coast, Qld

Mark undertook an independent peer review of modelling and associated impacts of a proposed marina at Salacia Waters development. The review was done in order to assist in resolving a dispute between Council and the proponent with regards to the representation in the model of hydraulic losses around the marina structures.

Florina Gardens Development, Gold Coast

The Florina Gardens development on the Gold Coast is located on the Nerang River floodplain. Gold Coast City Council engaged Mark to complete a peer review of the hydraulic modelling done by the proponent and an assessment against the planning scheme.

Key expert witness experience

Mark regularly prepares expert witness statements for both government and private sector clients in relation to flooding and Stormwater matters. The list below is a mix of VCAT and Planning Panel work in Victoria, Planning & Environment Court in Queensland and Land and Environment Court in NSW.

- Mills Crescent Development at Port Fairy, Vic
- Implementation of Special Building Overlay into planning scheme, City of Greater Geelong
- Masters Development at Corio, Victoria
- Development at San Remo, Victoria
- Halcyon Waters appeal, Gold Coast, Queensland
- Masters Development at Corio, Victoria
- Eastern Golf Course at Yering, Victoria
- St Patricks School, Macksville, NSW
- Claremont Street, South Yarra, Victoria
- Great Ocean Green Development, Apollo Bay, Victoria
- Grand Lakes Development at Lara, Victoria
- Caddys Road Rezoning at Lara, Victoria
- Manzeene Avenue Development at Lara, Victoria
- Subdivision at Metung, Victoria
- Subdivision at Aireys Inlet, Victoria
- Flooding appeal at Gardiner Rd Hawthorn
- Sheehan & Berry appeal, Gold Coast, Queensland
- Dunns Creek Road Dromana, Victoria
- Development at Walcourm Court, Launceston, Tasmania
- Pizzolato Development, Innisfail, Queensland
- Celledoni Development, Innisfail Queensland
- Barwon Heads Road Development, Victoria

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Jempson, M.A., Rogencamp, G.J., (2006), The Application and Benefits of 2D/1D Flood Modelling in Urban Developments, 1st *Association of Land Development Engineers Conference*, Gold Coast, Queensland, August 2006

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